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LANDSAT FOLLOW-ON EXPERIMENT - GULF OF MEXICO
MENHADEN AND THREAD HERRING RESOURCES INVESTIGATION

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October 1975

Type II Report for Period July 30 - October 31, 1975

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16. Abstract An investigation is being conducted cooperatively by Federal and State Government agencies and private industry to demonstrate the feasibility of using satellite data for enhancing the management and utilization of coastal fishery resources in the northern Gulf of Mexico. Menhaden (<u>Brevoortia patronus</u>) and thread herring (<u>Opisthonema oglinum</u>) were selected as target species in study areas located in the Mississippi Sound and off the coast of Louisiana. Correlations are being sought between the fishery resources and oceanographic parameters measurable from aerospace platforms from which models can be developed for predicting fish distribution in the northern Gulf of Mexico. Synoptic ground truth data were obtained from oceanographic and fishing vessels, offshore oil platforms, and fishery aircraft for correlation with data obtained from aircraft and satellites. The investigation is expected to produce new information on coastal water ecology, provide techniques for converting remotely acquired data into measurements of oceanographic parameters, identify satellite techniques for minimizing the search time required for commercial harvest and assessment of coastal fishery resources, and define requirements for future satellites.			
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Preface

This report covers the investigative period from July 30 to October 31, 1975 and represents the second progress report prepared since the investigation was formally initiated on April 29, 1975. Emphasis in this report is given to the data acquisition phase of the investigation as this phase was just recently completed.

Eight missions were completed over the Louisiana test site and seven over the Mississippi Sound. Three of these missions over each of the test sites involved extensive sea truth sampling, aircraft remote sensing, satellite coverage, and the acquisition of fishery information. The remaining missions were limited in scope to include fishing information and satellite coverage.

Data analyses to this point suggest that water color and turbidity (secchi disc extinction) will be useful parameters for predicting menhaden distribution.

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ABBREVIATIONS AND SYMBOLS

NASA	National Aeronautics and Space Administration
NMFS	National Marine Fisheries Service
NFMOA	National Fish Meal and Oil Association
LANDSAT-1	Land Satellite (No. 1)
LANDSAT-2	Land Satellite (No. 2)
JSC	Johnson Space Center
ERL	Earth Resources Laboratory
FEL	Fisheries Engineering Laboratory
NOAA	National Oceanic and Atmospheric Administration
NESS	National Environmental Satellite Service
NWS	National Weather Service
AOML	Atlantic Oceanographic and Meteorological Laboratory
GSFC	Goddard Space Flight Center
NSTL	National Space Technology Laboratories
USGS	United States Geological Survey
EROS	Earth Resources Observation Systems
OCSO	Outer Continental Shelf Operations
USCG	United States Coast Guard
NP3A	NASA Medium Altitude Remote Sensing Aircraft
SMS/GOES	Synchronous Meteorological Satellite/Geostationary Operational Environmental Satellite
LLLTV	Low Light Level Television
ISRS	Information Storage and Retrieval Systems
PRT-5	Precision Radiation Thermometer-5
MSS	Multispectral Scanner System
ERTS	Earth Resources Technology Satellite
MFMR	Multifrequency Microwave Radiometer
M2S	Modular Multispectral Scanner
CCT	Computer Compatible Tape
A/D	Analog to Digital
PCM	Pulse Code Modulated

LANDSAT MENHADEN AND THREAD HERRING RESOURCES INVESTIGATION

1. INTRODUCTION

- 1.1 REPORTING. This progress report is the second in a series under NASA Agreement Number S-54114, ID #20770, sponsored by the NASA Goddard Space Flight Center. It is a type II report covering the investigative period from July 30, 1975 to October 30, 1975.
- 1.2 OVERVIEW. This investigation is being conducted in two test sites off the coasts of Mississippi and Louisiana (Figures 1.1 and 1.2). A description of these test sites was given in the last progress report and will not be repeated here. The primary target species is the Gulf menhaden (Brevoortia patronus); the secondary target species is the thread herring (Opisthonema oglinum). Both species form large schools with numbers frequently exceeding one hundred thousand per school. The schools are considered near-surface pelagics which suggests an immediate application of remote sensing techniques. Both species are harvested for conversion into high protein fish meal and oils. Approximately 600,000 tons of menhaden are taken from the Gulf annually representing almost 26 percent of the entire domestic harvest of all fish. While the standing stock of thread herring in the Gulf is believed to exceed that of the menhaden, the catch averages less than 1 percent of the average menhaden landings. The thread herring is truly a latent resource and one which is beginning to receive increased attention from several fishing companies.

The investigation was formally initiated on April 29, 1975, by a memorandum from the Director of the National Marine Fisheries Service to Mr. L. H. Meredith, Assistant Director, Goddard Space Flight Center, in which the Director stated, "the National Marine Fisheries Service is pleased to accept this new agreement (No. S-54114 ID #20770)..." Unofficially, however, the investigation began back as early as November 1974 when a series of meetings began with representatives of the National Fish Meal and Oil Association. These meetings were designed to formulate a plan with the industry for the investigation and in particular to acquire their interest and support.

The investigation was designed to extend over an 18-month period with the first 6 months dedicated primarily to planning and data acquisition (field operations), and the remaining 12 months used for data analysis and report preparation. This second in a series of type II progress reports emphasizes the field operations phase of the investigation.

- 1.3 OBJECTIVES. The primary objective is to verify the relationship of certain coastal environmental parameters which are observable from aerospace platforms to the distribution and abundance of Gulf menhaden, a commercially important fish in the northern Gulf of Mexico. A secondary objective is to establish relationships of remotely sensed environmental parameters to a fish with potential commercial importance, thread herring.

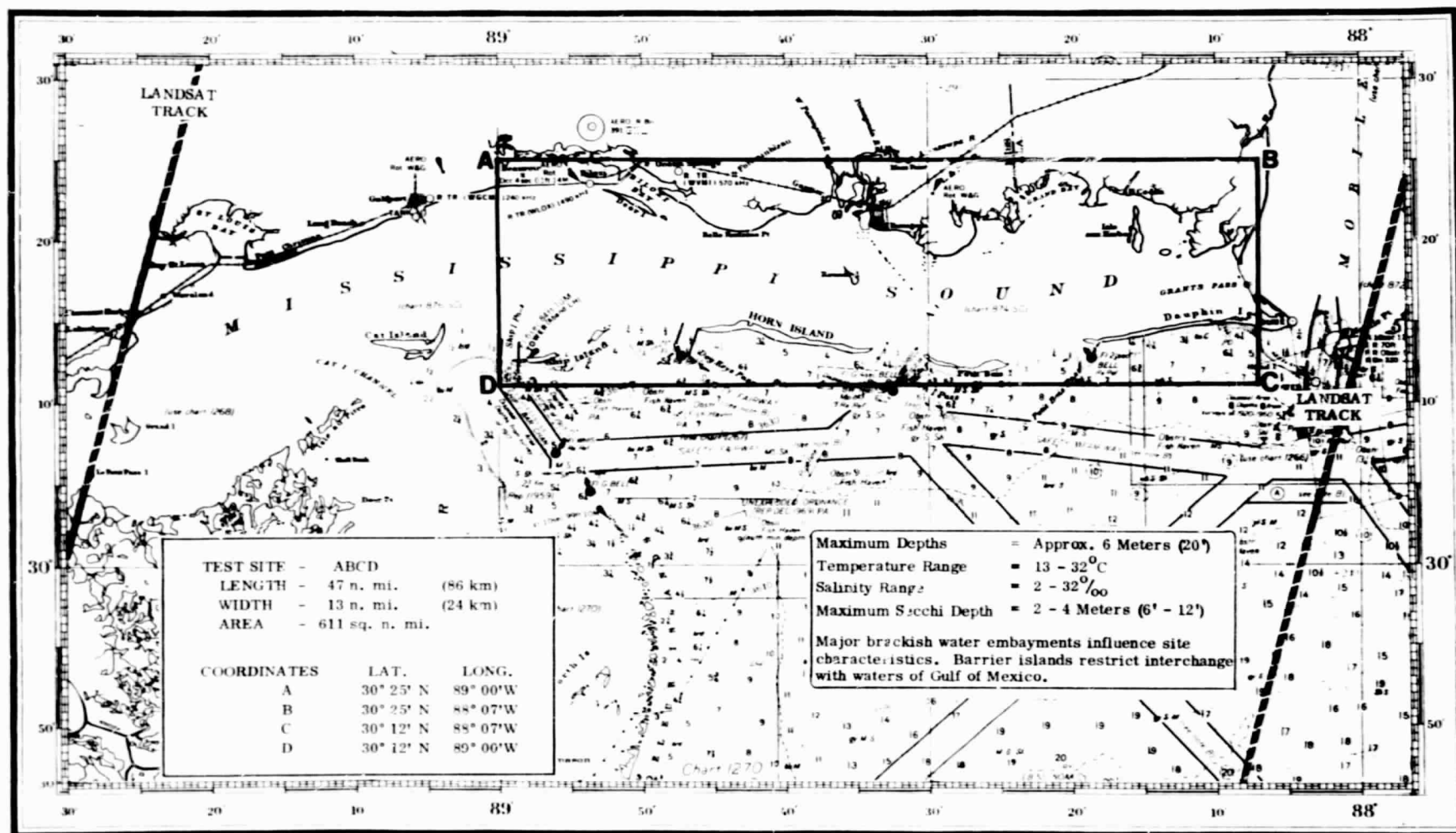


Figure 1.1 LANDSAT FOLLOW-ON EXPERIMENT TEST SITE (MISSISSIPPI SOUND)

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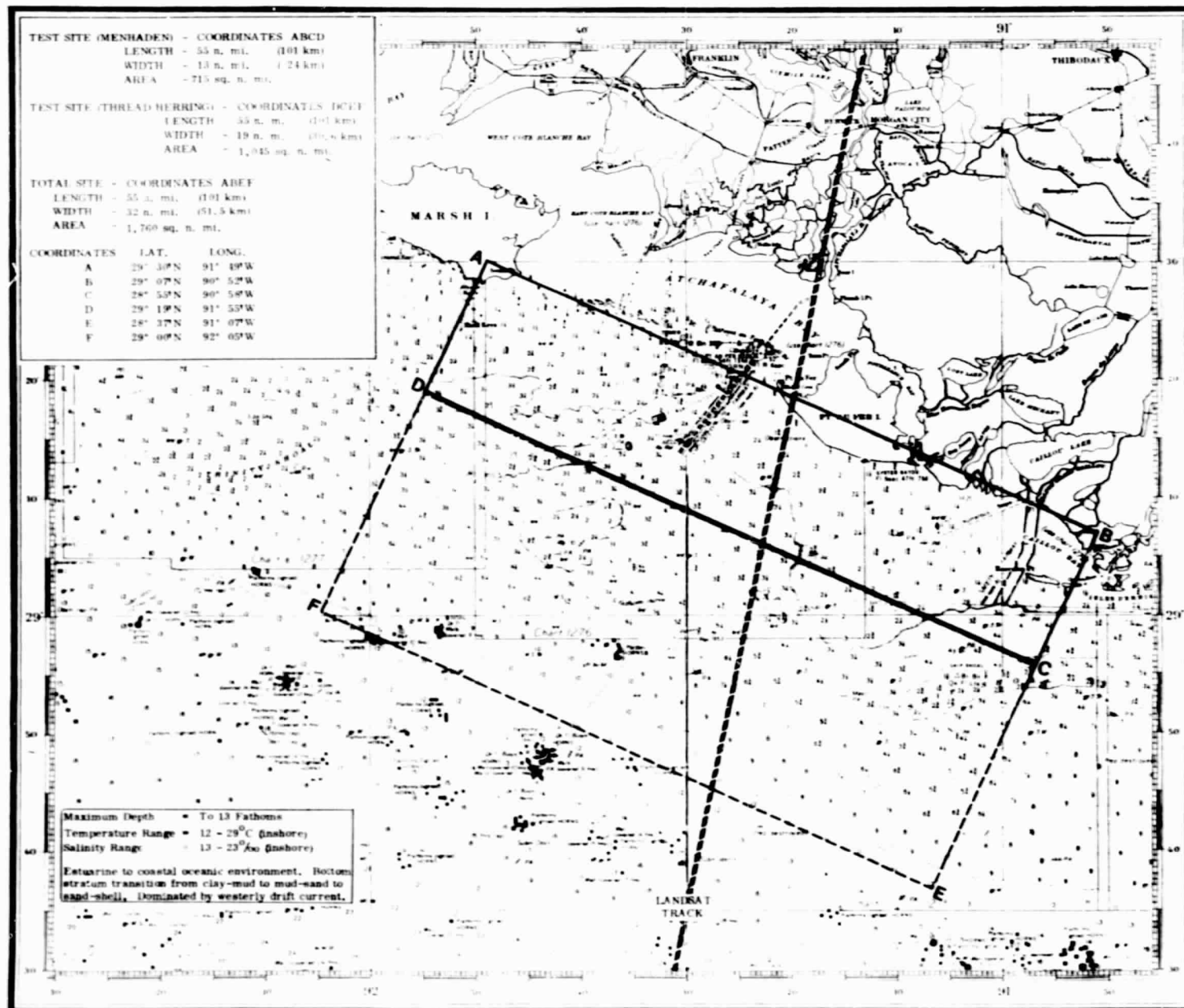


Figure 1.2 LANDSAT FOLLOW-ON EXPERIMENT TEST SITE (OFFSHORE LOUISIANA)

Sub-objectives of the multi-phased investigation are:

- Confirm utilization of aerospace data as inputs for a distribution prediction model for adult menhaden in the Mississippi Sound.
- Test utilization of aerospace data as inputs for a distribution prediction model for adult menhaden over the entire season of menhaden availability in the Mississippi Sound.
- Test utilization of aerospace data as inputs for a distribution prediction model for adult menhaden throughout the commercial fishery range in the northern Gulf of Mexico.
- Test utilization of aerospace data as inputs for a distribution prediction model for adult thread herring off the coast of Louisiana.
- Continue development of techniques for the application of remote sensing data to living marine resource assessment and utilization.

2. INVESTIGATION PARTICIPANTS AND ORGANIZATIONS

- 2.1 PRINCIPAL AND CO-INVESTIGATIVE PARTICIPANTS.** This experiment is a cooperative venture whose principal participants originate from various Federal agencies and commercial fishing companies. They are as follows:

National Oceanic and Atmospheric Administration (NOAA)

National Marine Fisheries Service (NMFS)

Southeast Fisheries Center

Fisheries Engineering Laboratory

Pascagoula Laboratory

National Aeronautics and Space Administration (NASA)

Earth Resources Laboratory (JSC/EKL)

National Fish Meal and Oil Association (NFMOA)

- 2.2 ASSOCIATED GROUPS AND AGENCIES.** Various groups and agencies who have and are providing assistance in one form or another to the Principal and Co-Investigative elements within the experiment are as follows:

National Oceanic and Atmospheric Administration (NOAA)

National Marine Fisheries Service (NMFS)

Southeast Fisheries Center

Miami Laboratory

Atlantic Estuarine Fisheries Center

National Environmental Satellite Service (NESS)

National Weather Service (NWS)

Atlantic Oceanographic and Meteorological Laboratory (AOML)

National Aeronautics and Space Administration (NASA)

Johnson Space Center (JSC)

Goddard Space Flight Center (GSFC)

National Space Technology Laboratories (NSTL)

Department of the Interior

United States Geological Survey (USGS)

Earth Resources Observation Systems (EROS)

Outer Continental Shelf Operations (OCSO)

United States Coast Guard (USCG)

Nicholls State University

Four Oil Companies

- 2.3 **ORGANIZATIONAL STRUCTURE.** The organizational structure of the investigation is composed of the principal and co-investigative participants. These participants along with their primary functional responsibilities are presented in Figure 2.1. The principal investigator is assisted in meeting his responsibilities by an advisory group composed of representatives from each participating agency or group. The NFMOA provides advice on utilization aspects of the investigations while NASA advisors insure that the investigation maximizes the use of appropriate remote sensing technology. The NMFS advisors provide advice on experimental design and analyses related to resource management.

Each of the five member companies of the NFMOA participating in the investigation appointed one or more people from their companies to represent them during the planning, data acquisition, data analysis, and report preparation phases of the investigation. These people, referred to hereafter as NFMOA cooperators, are serving as the principal interfaces between their respective companies and the other participants. They are

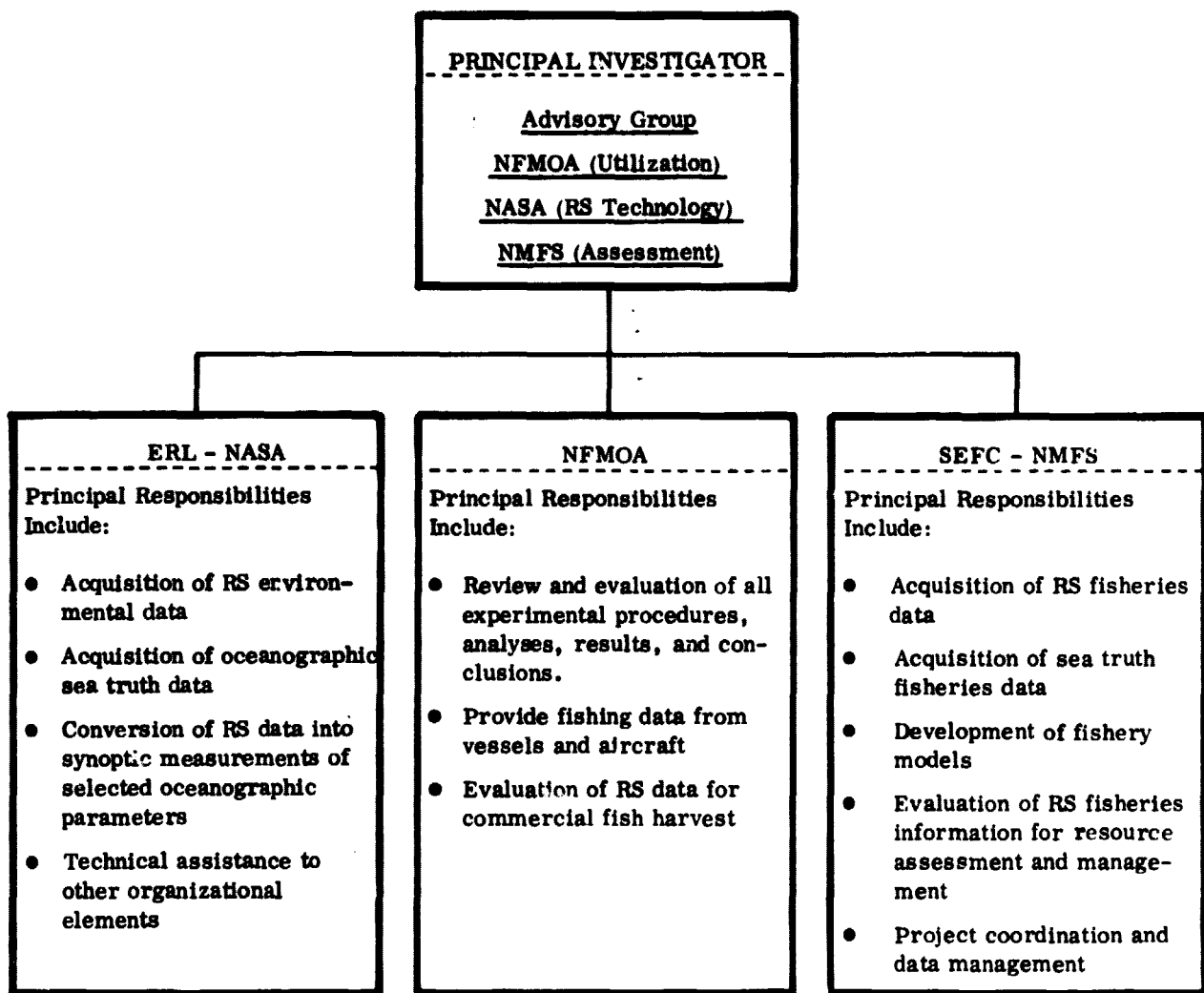


Figure 2.1 Functional Organization Structure and Principal Responsibilities for the LANDSAT Follow-On Investigation

also serving in a review capacity for all planning, experimental procedures, field operations and data analyses matters relating to the investigation through a series of formal meetings held every two-three months at the Fisheries Engineering Laboratory. Matters of policy, however, are generally referred to the Director, NFMQA, after discussion with the cooperators.

3. EXPERIMENTAL DESIGN

3.1 OVERVIEW. The experimental rationale and design used for the 1975 LANDSAT Menhaden and Thread Herring Resources Investigation is similar to that developed for the LANDSAT-1 (ERTS-1) 1972-1973 menhaden study in the Mississippi Sound and the 1973 Skylab Oceanic Gamefish Experiment. Essentially it consists of trying to predict the commercial availability of menhaden and thread herring based on measurements of selected oceanographic parameters derived from satellite and aircraft remotely sensed data. It consists of four discrete experimental units:

- Aerospace remotely sensed data
- Oceanographic data
- Fish distribution and abundance
- Fishery utilization data

The units are groupings or banks of data and are related one to another in the manner shown in Figure 3.1. Aerospace remotely sensed data are used to infer oceanographic data which are then used to predict the distribution and abundance of a fish species. This latter information is then used to predict likely areas for harvest of the resource.

3.2 DESIGN MODEL. The experimental design selected for this investigation is based on the LANDSAT-1 menhaden study. It drives off the rationale given in Figure 3.1. Data are collected through field operations to satisfy the needs of each experimental unit, then attempts are made to relate the units through statistical analyses. A better idea of how the design operates can be provided by viewing the experimental rationale in the context of a model (Figure 3.2).

The most critical components of the model and of the experimental design are shown in Figure 3.2; they are the links between the experimental units. Aerospace remotely sensed data are converted into oceanographic information by oceanographic models. In some cases, such as for surface water temperature and salinity, models already exist which appear to be applicable to this investigation. In other cases, however, such as for water chlorophyll and turbidity, models may have to be developed or extensively modified to satisfy the needs of the experiment.

The link between oceanographic data and fish distribution and abundance was partially satisfied during the LANDSAT-1 menhaden investigation through

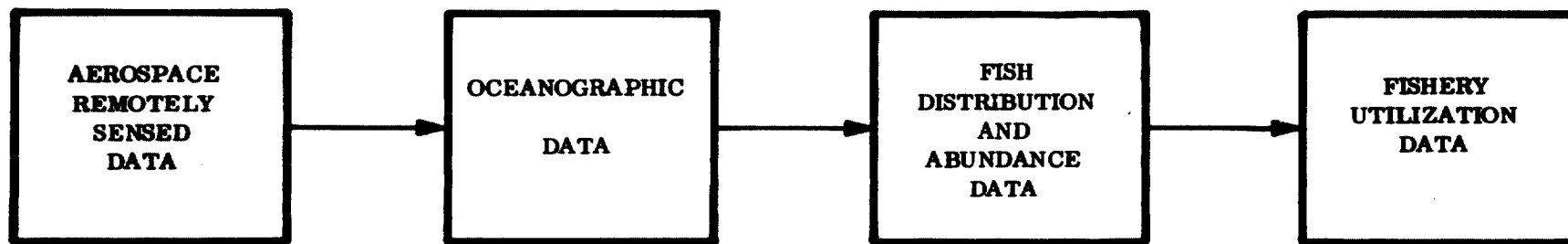


Figure 3.1 Overview of the Experimental Rationale Used in the LANDSAT Menhaden and Thread Herring Investigation

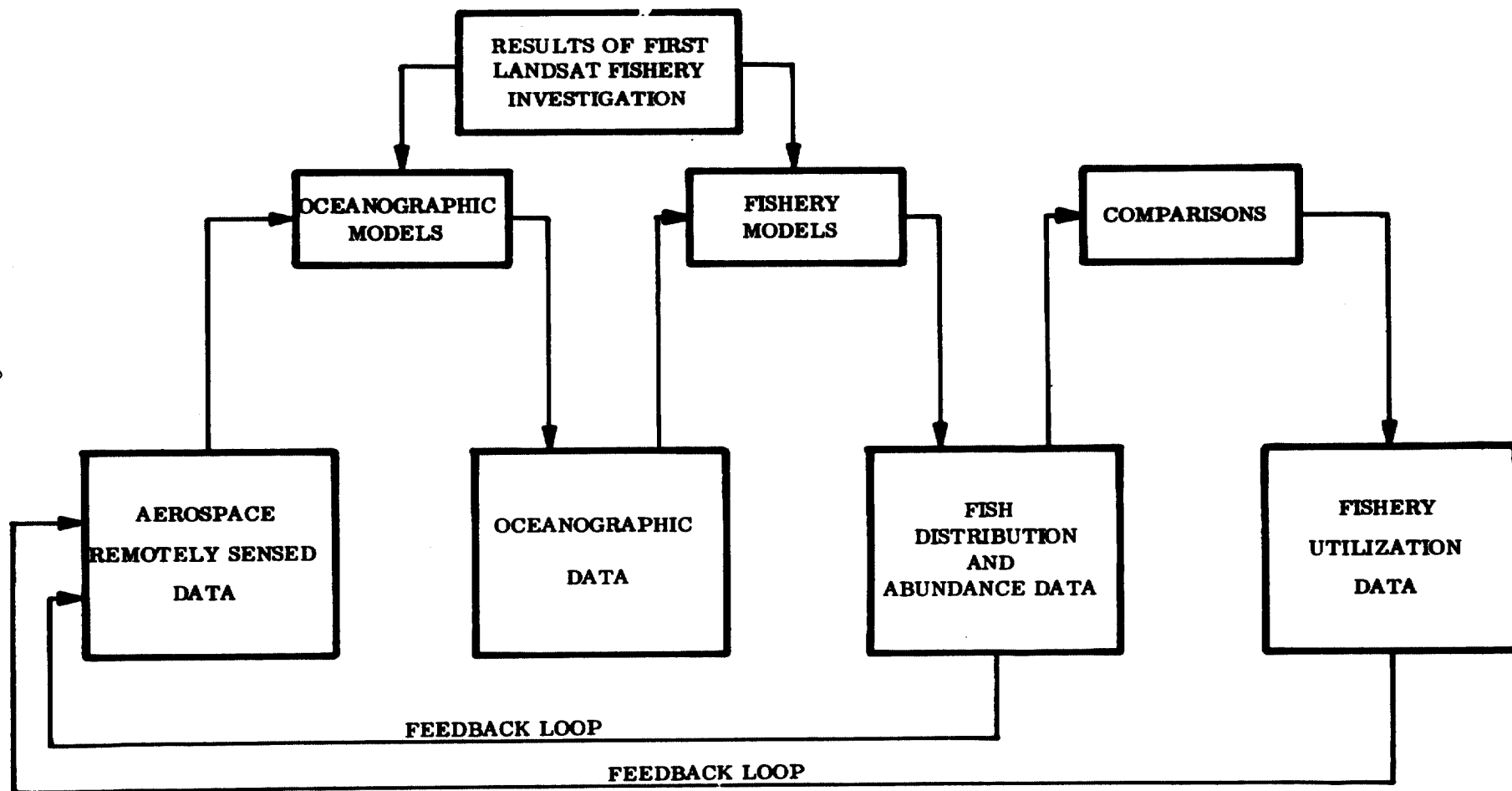


Figure 3.2 Model of the Experimental Rationale Used in the LANDSAT Menhaden and Thread Herring Investigation

the development of eight empirical models. However, due to their empirical nature, they may only be applicable to menhaden in the Mississippi Sound. Models will be modified to satisfy the test area west of the Mississippi River. Model development, modification, and/or verification will be accomplished through a discriminate function analysis similar to the analysis used during the first investigation.

The final link between fish distribution and abundance and fishery utilization will be provided through a direct comparison of predicted or known areas of fish concentrations with locations of commercial catches in the two experimental areas. This link establishes fish availability to the commercial fleet and serves as a check on the overall validity of predicted values.

Within the experimental model shown in Figure 3.2 there are two feedback loops to the aerospace remote sensing unit and two feedback loops which control or verify inputs into the oceanographic and fish distribution and abundance data units. These feedback loops are an essential part of the experimental design.

The feedback loops from the fish distribution and abundance and the fishery utilization units to the aerospace remote sensing unit serve similar purposes. In particular, they define how remotely sensed data should be analyzed to maximize the usefulness of the data. For example, it may be necessary and certainly appropriate to define a new set of oceanographic parameters upon which to base the fishery models. At present, classical parameters such as temperature, turbidity, chlorophyll, and salinity are being used. To measure these parameters remotely requires data manipulations and filtering which may eliminate essential information. Ultimately, a new set of parameters based primarily on data which can be obtained remotely may be defined.

For example: Remote color measurements are normally used to estimate chlorophyll and turbidity conditions in a water mass. Selected discrete portions of the light spectrum are multiplied, divided, and/or summed to yield these measurements. Portions of the spectrum which do not significantly increase precision or accuracy are omitted. These omitted portions, however, may be manifesting water quality conditions which influence fish distribution and abundance directly in a way unexplained by either chlorophyll or turbidity, such as zooplankton concentrations and the interaction of zooplankton. The specific portions of the light spectrum which would yield measurements of these latter factors have not been identified. However, since water color reflects an integrated view of all of these factors, the use of water color measurements directly in fishery models, instead of first converting them into classical oceanographic parameter measurements, may be appropriate.

The feedback loops to the test and calibrate "boxes" of the oceanographic and fishery models are used exactly for that purpose. That is, a small amount of sea truth oceanographic data will be collected to test and calibrate oceanographic measurements computed from aerospace remotely

sensed data. In addition, a limited amount of oceanographic data collected from selected fishing vessels will be used to check predictions of the fishery models.

4. DATA ACQUISITION OPERATIONS

4.1 OVERVIEW. The data acquisition activities were grouped into two categories: Main and supplementary day missions. The main day missions were designed to provide the full complement of data required for development and/or refinement of oceanographic and fishery models; the supplementary day missions were designed to provide data for testing and evaluating the models. The scope of the supplementary day missions was significantly less than that of the main day missions.

4.2 RESPONSIBILITIES. The three primary participants in the investigation maintained responsibility for specific data acquisition needs during the data acquisition phase of the investigation. The NFMOA was responsible for acquiring data from the fishing vessel captains and spotter pilots and providing fishing vessel access to scientific observers on a non-interference basis. They also provided cloud cover, sea state, and fishing data reports on a near real time basis to the principal investigator prior to and during the main day missions.

The NMFS, through its Fisheries Engineering Laboratory, was responsible for training and placing scientific observers on selected oil platforms during the Louisiana test site main day missions, scientific observers on selected fishing vessels (identified in cooperation with the NFMOA), providing a chartered photographic aircraft for coverage of the offshore portion of the Louisiana test site, coordinating and collecting NFMOA reports from fishing vessel captains and spotter pilots, and acquiring (ordering) LANDSAT 1 and 2 data.

The Earth Resources Laboratory was responsible for providing three staffed oceanographic vessels for acquiring sea truth data on each of the main day missions, aircraft remote sensing coverage of the two test sites (ERL Beechcraft and JSC NP3A), establishing and maintaining a field communications system, and for providing a command post for the main day missions.

The Principal Investigator was responsible for the direction, coordination and integration of all field operations. He was assisted by field operations managers from FEL and ERL and by an industry (NFMOA) liaison investigator provided by the NMFS Pascagoula Laboratory.

4.3 PLATFORMS, PROCEDURES, AND PARAMETERS. As both FEL and ERL are in the process of preparing comprehensive data reports which will detail the platforms, equipment, procedures, and parameters measured during the data acquisition phase of the investigation, only a summarized version of that information will be presented here.

Table 4.1 summarizes the main day mission data acquisition platforms and principal parameters. Supplementary day missions provided data only from fishing vessels without scientific observers, NFMOA spotter pilots, and the LANDSAT and SMS-GOES satellites. With one exception, LANDSAT 1 was used for coverage of the Louisiana test site and LANDSAT 2 for the Mississippi Sound. The exception occurred late on the investigation when LANDSAT 2 was used for a main day mission off Louisiana after a report from the Technical Monitor that LANDSAT 1 might be deactivated due to an attitude control failure.

Besides the parameters indicated in Table 4.1, a few additional measurements were obtained from the oceanographic sea truth vessels at selected stations. These measurements included air temperature, relative humidity, wind direction and speed, sea state, visibility, barometric pressure, transmissivity, relative irradiance, suspended matter (total mass), and fluorometric measurements of chlorophyll (continuous flow).

Remote measurement systems acquiring data from the ERL Beechcraft included a PRT-5 (temperature), an RS-18MS (color), and photography (location and fish detection). Remote measurement systems acquiring data from the NASA NP3A included a multifrequency microwave radiometer coupled with a PRT-5 (salinity), a modular multispectral scanner (color), and a bore site camera (location). The photographic aircraft acquired photographic imagery, using an RC-10 camera (6-inch lens and 9-inch film format) supplied with Kodak Aerochrome infrared film (2443) and a Wratten 12 Kodak filter. NFMOA spotter pilots used visual observations to locate, quantify, and identify fish.

Training sessions for the scientific observers going aboard fishing vessels and platforms were held prior to the field operations to familiarize the observers with the scientific methodology and proper use of sampling equipment. The development and subsequent use of systematic procedures and techniques for data collection were essential to assure minimization of biases and errors due to individual observer characteristics. The materials and equipment used for making measurements from the fishing vessels and oil platforms was provided in portable, self-contained sea kits that could be easily handled by two people. The compact kits were designed to allow efficient use of limited space aboard vessels and platforms and also provide flexibility for rapid replenishment and relocation when necessary. Equipment failure during the field operations was minimal and most data losses were due to rough seas or routine vessel maneuvering during fishing activities. Included in each sampling kit was a series of charts, tables, and photographs bound in a loose-leaf notebook which depicted the objectives, rationale, and background of the investigation. This information was used by the individual observers to brief interested parties on the investigation.

Table 4-1. Main Day Mission Data Acquisition Platforms and Parameters

Parameter	SURFACE				AIRCRAFT					SATELLITES	
	Fish. Vess. without Observer	Fish. Vess. with Observer	Oceano- graphic Vessel	Oil Platform	NP3A	NASA ERL Aircraft	NFMOA Spotters	NMFS Photo	NMFS LLLTV*	LANDSAT	SMS/GOES
Salinity		X	X	X	X						
Chlorophyll		X	X	X	X*	X				X	
Color		X	X	X	X*	X				X	
Transparency		X	X	X	X*	X				X	
Temperature		X	X	X	X	X					
Water Depth		X	X	X							
Fish School Locations			X			X	X	X	X		
Location of Fish Catches	X	X				X		X			
Meteorology			X				X				X

*Louisiana study area only.

Flight lines and procedures for the remote sensing aircraft and locations of the sea truth sampling stations have been presented elsewhere and as such will not be presented here except to state that they were designed to maximize coverage of the test sites during mission windows. Sampling from the fishing vessels was attempted every time a set (fish catch) was made and at other locations where fish were not observed. These samples were acquired on a non-interference basis with the fishing operations and depended significantly on the initiative and ingenuity of the scientific observers.

- 4.4 TYPICAL MAIN DAY MISSIONS. At least 7 days before a main day mission, a planning meeting was conducted to specifically review the aircraft, vessels, personnel, flight lines, sea truth sampling stations, times, communications, and operational responsibilities involved in the mission. The results of these meetings were recorded and placed into an operations plan which was distributed to the participants. Status review meetings were then held every day prior to the mission to coordinate activities, make last minute adjustments to the operations plan, and to make the decision to terminate or continue mission implementation.

Normally, the fishing vessel observers boarded their respective vessels on Sunday night regardless of mission day. A Sunday boarding was required because the vessels would normally depart their ports on Sunday and not return until the following Friday or Saturday night. Observers going aboard oil platforms were flown out to the platforms on the day prior to the main day mission and returned on the evening of the mission day. Helicopter transportation service was provided by the Outer Continental Shelf Operations office of the United States Geological Survey. The fishing vessels observers acquired samples throughout the fishing week while the platform observers acquired data only on the mission day.

The logistics for the Louisiana test site missions were more complex than those for the Mississippi Sound due primarily to the distances involved. The ERL vessel (ERL) generally would depart its home port in Gulfport three days prior to the main mission day to insure ample time for arriving on station. The oceanographic vessels (ERL and two chartered vessels) were boarded at Grand Isle, Louisiana, by the sampling crews the day before the mission and would spend the night on station. The Mississippi Sound missions were operated out of Gulfport and did not require the samplers to spend the night at sea.

A communications command post was established at Grand Isle initially and later at Houma, Louisiana for the Louisiana test site missions. A command post for the Mississippi Sound missions was maintained at NSTL. The command posts were manned on the day prior to the main day mission. Normally, the people manning the command post included the FEL and ERL operations managers, the principal investigator, the industry liaison investigator and a radio operator. The command post functioned primarily to coordinate activities, monitor schedules, make any necessary last

minute adjustments to the schedule, and to abort or continue with the field activities depending on weather conditions and/or platform failures.

On the day prior to a main mission day, the industry liaison investigator would contact selected NFMOA spotter pilots to ascertain where menhaden and thread herring were being observed or caught. This information was especially critical for the Louisiana test site as the offshore flightlines were selected to maximize the probability of flying over areas with fish. Normally, several NFMOA pilots would fly the entire Louisiana test site to acquire this information. At sunrise on the day of the mission, NFMOA spotter pilots would contact the ERL to relay information on weather and cloud cover conditions to the command post. The ERL, in turn, would relay information back to the spotter pilots concerning mission status and especially any schedule changes in ERL and NP3A aircraft operations. This was done to minimize the dangers associated with mid-air collisions.

The NP3A operated out of Houston, Texas or Nashville, Tennessee, and the ERL Beechcraft out of Stennis Field, Mississippi, for all main day missions. The NMFS chartered aircraft flew out of Houma, Louisiana. Constant communications with the aircraft were maintained via telephones prior to takeoff and radios through the ERL during flight operations.

A mission debriefing was held the week following the week of main day mission. All principal mission participants attended the meeting so that a complete review could be made of the operations. This debriefing was held primarily to uncover problems so that they could be corrected prior to the next mission.

It should be noted that with the exception of data collection from fishing vessels and spotter aircraft, all main day data acquisition activities were limited to the mission day only. As the scientific observers had to remain aboard the fishing vessels throughout the fishing week they performed sampling functions the entire time they were at sea. Fishing vessel captains and spotter pilots acquired data the day before, the day of, and the day after the main day missions so that information on general movement patterns of the fish could be developed.

- 4.5 TYPICAL SUPPLEMENTARY DAY MISSIONS. The normal supplementary day mission involved only vessel captains and spotter pilots completing data forms provided by the industry liaison investigator. These missions were designed to coincide with LANDSAT 1 and 2 orbits. The captains and pilots were requested to provide fish catch and location information the day before, the day of, and the day after the supplementary day mission.

5. ACCOMPLISHMENTS

The first six official months of this investigation have been concerned primarily with planning, coordination, and data acquisition and processing. Very little time has been devoted to data analysis except in the sense of data quality verification and to establish analytical priorities.

5.1 DATA ACQUISITION AND PROCESSING. The field operations phase of this investigation was highly successful. This success must be attributed to the high degree of cooperation and mutual interest extended to the investigation by NASA aircraft management and operations personnel, fish plant managers, fishing vessel personnel, spotter pilots, scientific observers, members of the petroleum community, the U. S. Geological Survey, and in general everyone who participated in the investigation. Throughout all of the missions, not one had to be deleted or curtailed due to availability of space for observers aboard fishing vessels, observer absence, assignment of temporary quarters for observers on oil platforms, access to helicopter service to and from offshore platforms, or any other such factor that might stem from improper coordination or management or lack of interest by a participant.

Figures 5.1 and 5.2 summarize the missions undertaken in support of the investigation. The first two main day missions in the Louisiana test site (Figure 5.1) operated as planned with all platforms functioning and acquiring data. The third scheduled main day mission, however, was aborted due to a reported mechanical failure aboard LANDSAT 1. This latter mission was rescheduled to coincide with an orbit of LANDSAT 2 on August 20, 1975. As the scientific observers were already aboard the fishing vessels before the decision was made to abort the July 29th mission, they were instructed to continue acquiring data. These data will be used as an added check of the models developed from data acquired during the main day missions.

While all of the surface and aircraft platforms performed satisfactorily during the Louisiana main day missions, it appears that most of the LANDSAT data are of marginal quality. This marginal quality is due primarily to excessive cloud cover over much of the test site and especially over areas where menhaden and thread herring were located. The full impact of these marginal data on the investigation is still uncertain as most of the data were just received. If these data are unusable, the investigation will concentrate on RS-18 data which are redundant to those from LANDSAT MSS and do appear satisfactory.

The first two scheduled main day missions for the Mississippi Sound test site operated as planned (Figure 5.2). The third main day mission (July 31, 1975) was aborted due to inclement weather (100 percent overcast) and unavailability of the NP3A. This latter mission was rescheduled to September 5, 1975, at which time all platforms functioned satisfactorily except for the ERL Beechcraft which experienced a mechanical failure.

LANDSAT data for the May 20th mission appear to be acceptable for analysis. LANDSAT data for the May 2nd mission are unacceptable due to a light hazy overcast (100%) and it is doubtful that the last main day mission will yield useful data because of excessive cloud cover (imagery ordered, but not received). Fortunately, RS-18MS data were acquired on the first two main day missions which appear acceptable for analysis.

Platform	Mission	Main	Main	Supple- mentary	Aborted Main ¹	Supple- mentary	Resched- uled Main	Supple- mentary	Supple- mentary
	Date	Apr 25	May 13	Jun 18	Jul 24	Aug 11	Aug 20	Aug 29	Sep 16
Fishing Vessels		X	X	X	X	X	X		X
Spotter Aircraft		X	X	X	X	X	X		X
Fishing Vessel Observers		X	X		X		X		
Research Vessels		X	X				X		
Oil Platforms		X	X				X		
ERL Aircraft		X	X				X		
NP3A Aircraft		X	X				X		
Photographic Aircraft		X	X				X		
LANDSAT I		X	X	X	X	X	X ²		X

¹ Mission aborted due to mechanical failure reported aboard LANDSAT I

² LANDSAT II

Figure 5.1 Summary of Louisiana Test Site Missions (1975)

Platform	Mission	Main	Main	Supple- mentary	Aborted Main ¹	Supple- mentary	Main ²	Supple- mentary
	Date	May 2	May 20	Jun 25	Jul 31	Aug 18	Sep 5	Sep 23
Fishing Vessels		X	X	X	X	X	X	X
Spotter Aircraft		X	X	X	X	X	X	X
Fishing Vessel Observers		X	X		X		X	
Research Vessels		X	X				X	
ERL Aircraft		X	X					
NP3A Aircraft		X	X				X	
LANDSAT II		X	X	X	X	X	X	X

1 Mission aborted due to inclement weather and unavailability of NP3A.

2 ERL Aircraft unable to complete mission due to inclement weather and mechanical failure.

Figure 5.2 Summary of Mississippi Sound LANDSAT Missions (1975).

Figures 5.3 - 5.8 summarize the status of sea truth and remotely acquired data for the Louisiana and Mississippi main day missions. In general, the sea truth data are believed to be of good quality. Fluorometer data from the May 2nd Mississippi Sound mission, however, appear to be of questionable quality. Remotely sensed data from the ERL Beechcraft (PRT-5, RS-18MS, and photographic) appear to be of acceptable quality and are in various stages of processing.

Unfortunately, very little data from the NP3A (PRT-5, M²S, microwave, and bore site camera) have been examined sufficiently to make quality judgements either because of lack of time or nonreceipt. Microwave data for the May 20th Mississippi Sound mission, however, have been reviewed and appear to be of good quality. Boresite camera data for the April 25th, May 2nd, 13th, and 20th missions are all of poor quality.

Perhaps one of the most perplexing aspects of this investigation so far has been a general failure of aerial photography to detect many fish. Originally, photography was selected as the principal means of acquiring fish distribution and abundance data for the main day missions. The photographic system (camera, film, and filter combination) used during the investigation was selected based on successes enjoyed in the past by the NMFS Pascagoula Laboratory in their work with photographic assessment of pelagic fish. The reason for this general failure is not understood and a special photographic multispectral and film comparison study was even flown to verify the earlier results. The study did not indicate any reason for change. A number of NFMOA spotter pilots after having been advised of this problem indicated that they too were having difficulty seeing fish directly and were relying more on environmental manifestations of the fish such as mud roils, etc. Whatever the reason is, however, the fact remains that aerial photography cannot serve as the primary means for establishing fish distribution patterns on any of the main day missions.

The fish distribution and abundance data provided by the fishing vessel captains and spotter pilots appears to be of good quality. Positioning accuracy is probably in the neighborhood of ± 1 nautical miles although many of the captains and pilots claim they do much better even without modern navigation equipment. Vessel captains provided data on 573 fish sets during the main day mission periods and 203 sets during the supplementary mission periods. Spotter pilots provided data on 152 fish school aggregations during the main day mission periods and 76 aggregations during the supplementary day mission periods. It should be noted that the aggregations mentioned frequently contained dozens of fish schools which often one or more vessels would spend an entire day fishing for.

- 5.2 DATA ANALYSIS. Thermal data from the ERL Beechcraft PRT-5 have been reduced and analyzed for the May 2nd and 20th Mississippi Sound missions and the May 13th Louisiana mission. An extract of thermal data from the Louisiana August 20th mission has also been processed and analyzed. These data are being keypunched for insertion into the LANDSAT data bank and will be presented in the form of contour maps.

LANDSAT DATA FLOW

Mission No. 1

Date 25 April

SURFACE TRUTH

Site Louisiana

Platform	Data Type	Data Acq.	Data Rec.	Data Veri.	Data Trans.	Data Veri.	Key Punched	Data Ret.	Data Veri.	Data to Comp.	Data Ret.	Data Anal.
Fishing Vessel	Fish Data	X	X	X	X	X	X	X	X	X	X	
	Oceano. Data	X	X	X	X	X	X	X	X	X	X	
Spotter Pilot	Fish Data	X	X	X	X	X	X	X	X	X	X	
Oceano. Vessel	Oceano. Data	X	X	X	X	X	X	X	X	X	X	
Oil Platform	Oceano. Data	X	X	X	X	X	X	X	X	X	X	
NMFS A/C Charter (photo)	Fish Loc. Data	X	X	X								
NASA Twin Beech	Fish Photo Data, KC1B	X	X	X	X	X	X					

REMOTE SENSING

Platform	Data Type	Data Acq.	Data Rec.	Quick Look	A/D, Decom. or Refo.	Raw Product	Correl. w/ Surf. Truth	Final Data Prod.	Sample Extract.	Data to Comp.	Data Ret.	Data Anal.
NASA Twin Beech	RS-18	X	X	X								
	PRT-5	No										
NASA NP3A A/C	MFMR	X	Partial									
	M ² S	No	X									
	PRT-5	X										
LANDSAT	Imagery	X	X	X	NA	X						
	CCT	X	X	X	X	X						

Figure 5.3 Platform and Data Flow Status Summary for the April 25, 1975 Louisiana Main Day Mission

LANDSAT DATA FLOW

Mission No. 2

Date 2 May

SURFACE TRUTH

Site Mississippi Sound

Platform	Data Type	Data Acq.	Data Rec.	Data Veri.	Data Trans.	Data Veri.	Key Punched	Data Ret.	Data Veri.	Data to Comp.	Data Ret.	Data Anal.
Fishing Vessel	Fish Data	X	X	X	X	X	X	X	X	X	X	
	Oceano. Data	X	X	X	X	X	X	X	X	X	X	
Spotter Pilot	Fish Data	X	X	X	X	X	X	X	X	X	X	
Oceano. Vessel	Oceano. Data	X	X	X	X	X	X	X	X	X	X	
NASA Twin Beech	Fish Photo Data, KC1B	X	X	X	X	X	X					

REMOTE SENSING

Platform	Data Type	Data Acq.	Data Rec.	Quick Look	A/D, Decom. or Refor	Raw Product	Correl. w/ Surf. Truth	Final Data Prod.	Sample Extract	Data to Comp.	Data Ret.	Data Anal.
NASA Twin Beech	RS-18	X	X	X	Partial							
	PRT-5	X	X	X	X	X	X	X	X			
NASA NP3A A/C	MFMR	X	X	X	NA	NA						
	M ² S	No										
	PRT-5	X										
LANDSAT	Imagery	X	X	X	NA	X						
	CCT	X	Not Ordered									

Figure 5.4 Platform and Data Flow Status Summary for the May 2, 1975 Mississippi Sound Main Day Mission

LANDSAT DATA FLOW

Mission No. 3

Date 13 May

SURFACE TRUTH

Site Louisiana

Platform	Data Type	Data Acq.	Data Rec.	Data Veri.	Data Trans.	Data Veri.	Key Punched	Data Ret.	Data Veri.	Data to Comp.	Data Ret.	Data Anal.
Fishing Vessel	Fish Data	X	X	X	X	X	X	X	X	X	X	
	Oceano. Data	X	X	X	X	X	X	X	X			
Spotter Pilot	Fish Data	X	X	X	X	X	X	X	X	X	X	
Oceano. Vessel	Oceano. Data	X	X	X	X	X	X	X	X	X	X	
Oil Platform	Oceano. Data	X	X	X	X	X	X	X	X			
NMFS A/C Charter (photo)	Fish Loc. Data	X	X	X								
NASA Twin Beech	Fish Photo Data, KC1B	X	X	X	X	X	X					

REMOTE SENSING

Platform	Data Type	Data Acq.	Data Rec.	Quick Look	A/D, Decom. or Refo.	Raw Product	Correl. w/ Surf. Truth	Final Data Prod.	Sample Extract.	Data to Comp.	Data Ret.	Data Anal.
NASA Twin Beech	RS-18	X	X	X								
	PRT-5	X	X	X	X	X	X	X	X			
NASA NP3A A/C	MFMR	X	Partial									
	M ² S	X	X									
	PRT-5	X										
LANDSAT	Imagery	X	X	X	NA							
	CCT	X	X									

Figure 5.5 Platform and Data Flow Status Summary for the May 13, 1975 Louisiana Main Day Mission

LANDSAT DATA FLOW

Mission No. 4

Date 20 May

SURFACE TRUTH

Site Mississippi Sound

Platform	Data Type	Data Acq.	Data Rec.	Data Veri.	Data Trans.	Data Veri.	Key Punched	Data Ret.	Data Veri.	Data to Comp.	Data Ret.	Data Anal.
Fishing Vessel	Fish Data	X	X	X	X	X	X	X	X	X	X	
	Oceano. Data	X	X	X	X	X	X	X	X			
Spotter Pilot	Fish Data	X	X	X	X	X	X	X	X	X	X	
Oceano. Vessel	Oceano. Data	X	X	X	X	X	X	X	X	X	X	
NASA Twin Beech	Fish Photo Data, KC1B	X	X	X	X	X	X					

REMOTE SENSING

Platform	Data Type	Data Acq.	Data Rec.	Quick Look	A/D, Decom. or Refor	Raw Product	Correl. w/ Surf. Truth	Final Data Prod.	Sample Extract	Data to Comp.	Data Ret.	Data Anal.
NASA Twin Beech	RS-18	X	X	X	X	X						
	PRT-5	X	X	X	X	X	X	X	X			
NASA NP3A A/C	MFMR	X	X									
	M ² S	No										
	PRT-5	X										
LANDSAT	Imagery	X	X	X	NA	X	X	X	X	NA	NA	X
	CCT	X	X	X	X	X						

Figure 5.6 Platform and Data Flow Status Summary for the May 20, 1975 Mississippi Sound Main Day Mission

LANDSAT DATA FLOW

Mission No. 5

Date 20 August

SURFACE TRUTH

Site Louisiana

Platform	Data Type	Data Acq.	Data Rec.	Data Veri.	Data Trans.	Data Veri.	Key Punched	Data Ret.	Data Veri.	Data to Comp.	Data Ret.	Data Anal.
Fishing Vessel	Fish Data	X	X	X	X	X	X	X	X	X	X	
	Oceano. Data	X	X	X	X	X	X	X	X	X	X	
Spotter Pilot	Fish Data	X	X	X	X	X	X	X	X	X	X	
Oceano. Vessel	Oceano. Data	X	X	X	X	X	X	X	X	X	X	
Oil Platform	Oceano. Data	X	X	X	X	X	X	X	X	X	X	
NMFS A/C Charter (photo)	Fish Loc. Data	X	X	X								
NASA Twin Beech	Fish Photo Data, KC1B	X	X	X								

REMOTE SENSING

Platform	Data Type	Data Acq.	Data Rec.	Quick Look	A/D, Decom. or Refo.	Raw Product	Correl. w/ Surf. Truth	Final Data Prod.	Sample Extract.	Data to Comp.	Data Ret.	Data Anal.
NASA Twin Beech	RS-18	X	X	X								
	PRT-5	X	X	X	X	X	X	X				
NASA NP3A A/C	MFMR	X										
	M ² S	X	X									
	PRT-5	X										
LANDSAT	Imagery	X										
	CCT	X										

Figure 5.7 Platform and Data Flow Status Summary for the August 20, 1975 Louisiana Test Site Main Day Mission

LANDSAT DATA FLOW

Mission No. 6
 Date 5 September
 Site Mississippi Sound

SURFACE TRUTH

Platform	Data Type	Data Acq.	Data Rec.	Data Veri.	Data Trans.	Data Veri.	Key Punched	Data Ret.	Data Veri.	Data to Comp.	Data Ret.	Data Anal.
Fishing Vessel	Fish Data	X	X	X	X	X	X	X	X	X	X	
	Oceano. Data	X	X	X	X	X	X	X	X	X	X	
Spotter Pilot	Fish Data	X	X	X	X	X	X	X	X	X	X	
Oceano. Vessel	Oceano. Data	X	X	X	X	X	X	X	X	X	X	
NASA Twin Beech	Fish Photo Data, KC1B	X	X									

REMOTE SENSING

Platform	Data Type	Data Acq.	Data Rec.	Quick Look	A/D, Decom. or Refor.	Raw Product	Correl. w/ Surf. Truth	Final Data Prod.	Sample Extract	Data to Comp.	Data Ret.	Data Anal.
NASA Twin Beech	RS-18	No										
	PRT-5	No										
NASA NP3A A/C	MFMR	X										
	M ² S	No										
	PRT-5	X										
LANDSAT	Imagery	X										
	CCT	X										

Figure 5.8 Platform and Data Flow Status for the September 5, 1975 Mississippi Sound Main Day Mission

A decision was made to concentrate analytical efforts relating to remotely sensed data on one main day mission for the purpose of refining the analysis techniques for use on other missions. The May 20th mission for the Mississippi Sound was selected because it appeared to suffer minimum cloud and haze interference problems. A "best" set of fish school location data was identified by developing transparent overlays showing fish school locations for each two hour interval during the mission day by platform (spotter pilots, fishing vessel sets, and aerial photography). The intent was to identify areas "with" and "without" fish for density slicing and supervised and unsupervised analyses of satellite and aircraft acquired color data. Selection of the "best" set of fish data was done by comparing data derived from the respective platforms considering the following location assignment priorities:

1. Aerial photography of fishing activities (most accurate)
2. Fishing vessel set reports
3. Spotter pilot reports
4. Aerial photography of fish schools.

The aerial photography of fish schools was given the lowest priority for the selection of "with fish" areas because in most cases there was ambiguity whether the schools were menhaden. Fishing vessel set location data were compared to location data from the spotter pilots to assure that the data sources were consistent. The selection of "with fish" areas was further restricted by considering only data acquired between 0600 and 1200 hours on the mission day. The selection of "without fish" areas, however, was unrestricted in that it involved data from all platforms throughout the entire day.

Following the selection of the "best" set of fish school locations, a preliminary analysis was performed on LANDSAT MSS data. Fish school locations were superimposed on each MSS band image and the image was density sliced on an I²S analog system. The slicing indicated that approximately 80 percent of the fish school locations could be isolated in a singular density category within the band 5 image. This observation is consistent with results from the 1972 LANDSAT-1 (ERTS) Menhaden Experiment. Work is currently underway which utilizes the LANDSAT CCT and supervised and unsupervised digital classification techniques.

Analysis of oceanographic data collected by scientific observers aboard fishing vessels was continued to check data quality and to help establish analytical priorities (i.e. analyze according to which parameters appear to correlate best with fish distribution patterns). These data were collected at or near the sites of menhaden capture. The rationale was to compare conditions where menhaden were caught over time and between test areas in hopes that a consistent relationship between one or more of the parameters and menhaden distribution might be found (e.g. all menhaden were caught in waters with a temperature of X° C). Data from

the sea truth oceanographic vessels were included in the analysis to provide an indication of general oceanographic conditions in the study areas at the time samples from the fishing vessels were acquired. The reader should be cautioned that while one would like to assume that the sea truth samples were taken at random, they were not. Indeed, they were taken from stations biased to insure coverage of areas suspected of having fish.

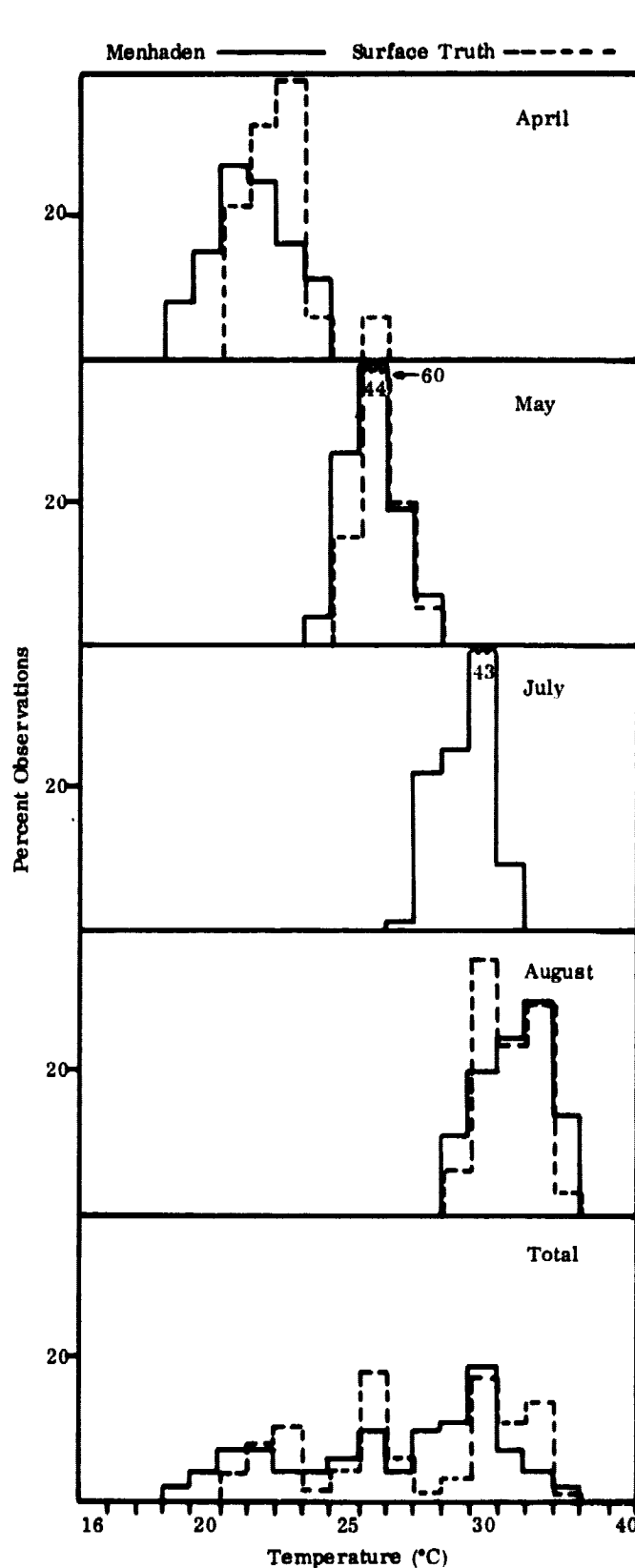
Figures 5.9 - 5.12 represent temperature, salinity, secchi disc, and color conditions, respectively, at locations of menhaden capture in the Louisiana test site and from surface truth stations. Based on these histograms, it appears that menhaden have little temperature or salinity preference but that their distribution may be predictable from secchi disc and color measurements. An examination of Figures 5.13 - 5.16, which provide similar information for the Mississippi Sound, suggests a similar situation; i.e. temperature and salinity have little influence on the distribution of menhaden, but secchi disc and color may have. Figure 5.17 compares conditions between test sites where menhaden were caught. This latter figure demonstrates very little similarity in temperature and salinity conditions where fish were caught between the two test sites. The similarity in the secchi disc and color histograms from the two test sites, however, suggests that the distribution of menhaden may be predictable from measurements of these two parameters. Analytical emphasis therefore has been placed on LANDSAT MSS and RS-18MS color data.

Unfortunately, an analysis of chlorophyll-a data from the fishing and surface truth vessels could not be completed in time for this report. A cursory review of these data, however, suggests that consistent relationship exists between menhaden captures and chlorophyll concentrations over time and between study areas.

- 5.3 FUTURE PLANS. Emphasis for the next month will be given to completing the computer storage of data from the main and supplementary day missions. Reports are being prepared by FEL and ERL which will detail their operational functions during the data acquisition phase of the investigation and contain listings and summaries of all sea truth data. Emphasis is also being placed on data analysis with most of this emphasis going to the conversion of aircraft remotely acquired data into measurements of oceanographic parameters and the correlation of color data with the distribution of menhaden.

Analytical work on thread herring must wait the successful conversions of aircraft remotely sensed data into oceanographic information because even though thread herring were frequently located by NFMOA spotter pilots, only a few sets were made on them by vessels with scientific observers aboard.

LOUISIANA TEST SITE TEMPERATURE



Sample Size	
Menhaden	Surface Truth

88	18
----	----

72	20
----	----

127	0
-----	---

44	33
----	----

331	71
-----	----

Figure 5.9 Comparison of Surface Measurements of Temperature from Sites of Menhaden Capture (solid lines) and Oceanographic Stations (broken lines) in the Louisiana Test Site

LOUISIANA TEST SITE SALINITY

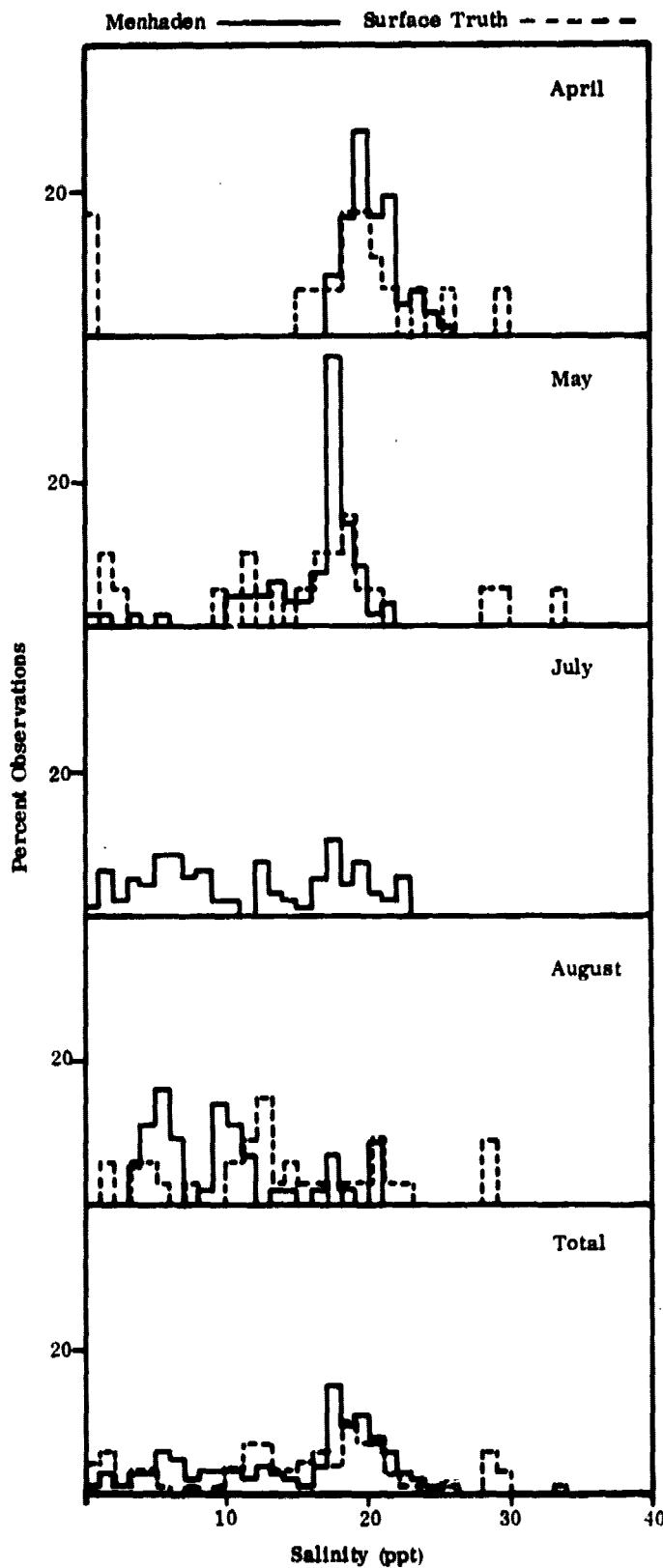
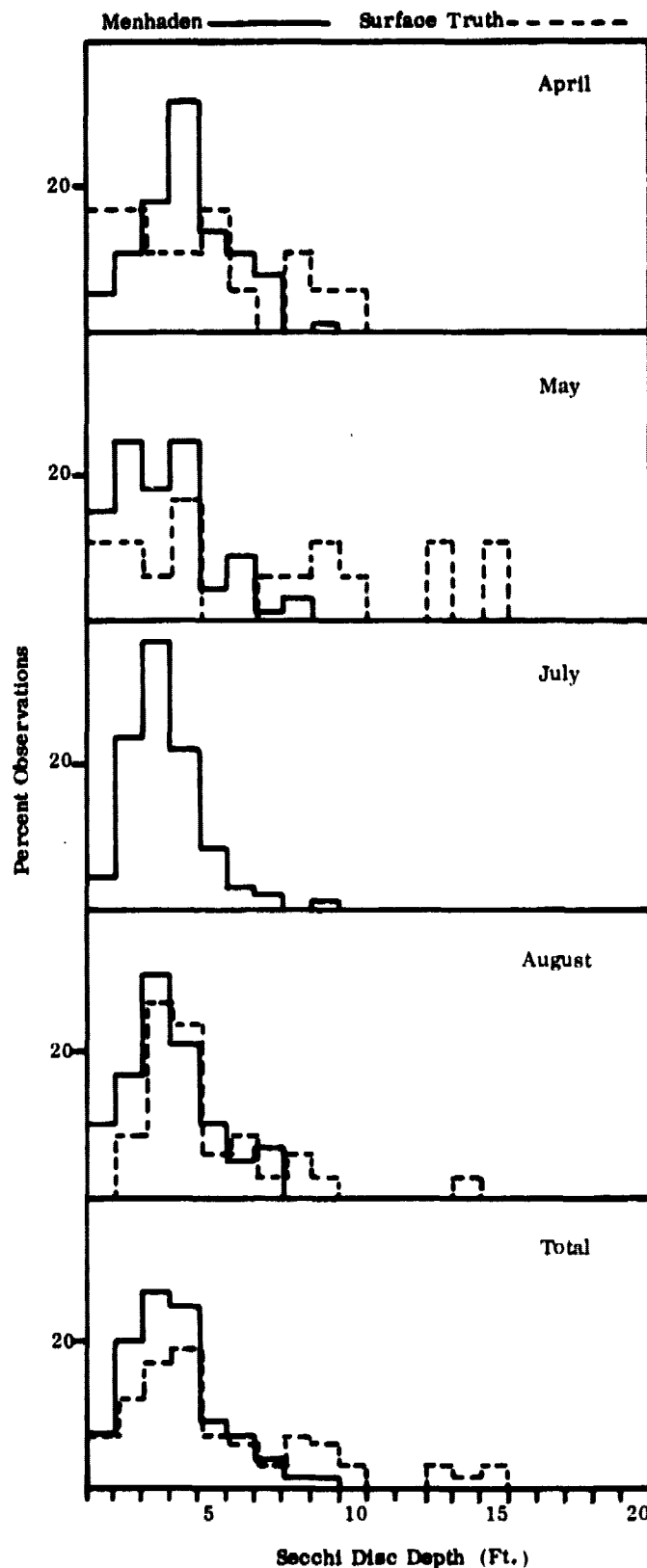


Figure 5.10

Comparison of Surface Measurements of Salinity from Sites of Menhaden Capture (solid lines) and Oceanographic Stations (broken lines) in the Louisiana Test Site

LOUISIANA TEST SITE SECCHI DISC DEPTH



Sample Size	
Menhaden	Surface Truth

88	18
----	----

68	18
----	----

131	0
-----	---

42	33
----	----

329	69
-----	----

Figure 5.11 Comparison of Secchi Disc Measurements from Sites of Menhaden Capture (solid lines) and Oceanographic Stations (broken lines) in the Louisiana Test Site

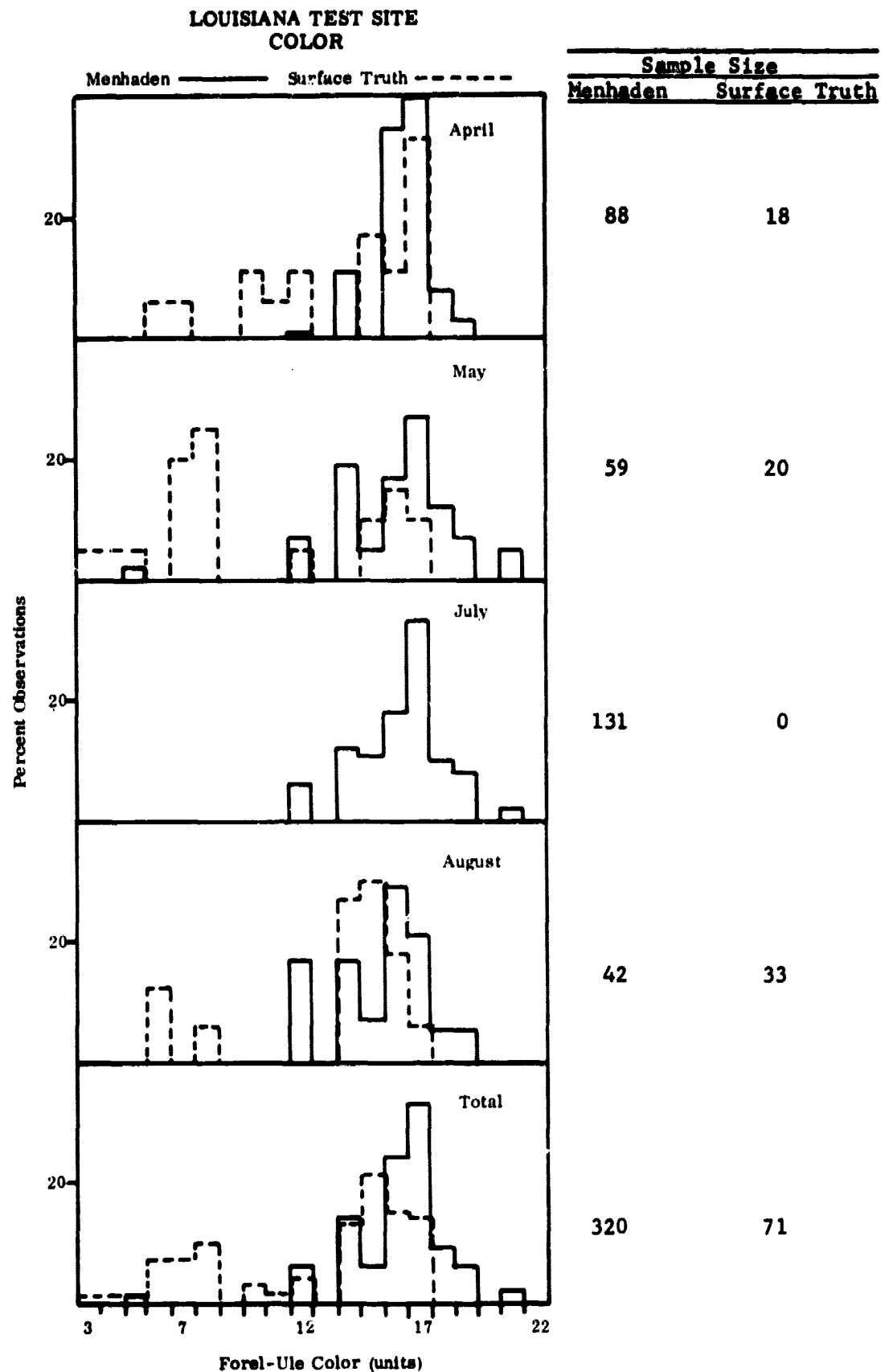


Figure 5.12 Comparison of Forel-Ule Color Measurements from Sites of Menhaden Capture (solid lines) and Oceanographic Stations (broken lines) in the Louisiana Test Site

MISSISSIPPI SOUND TEMPERATURE

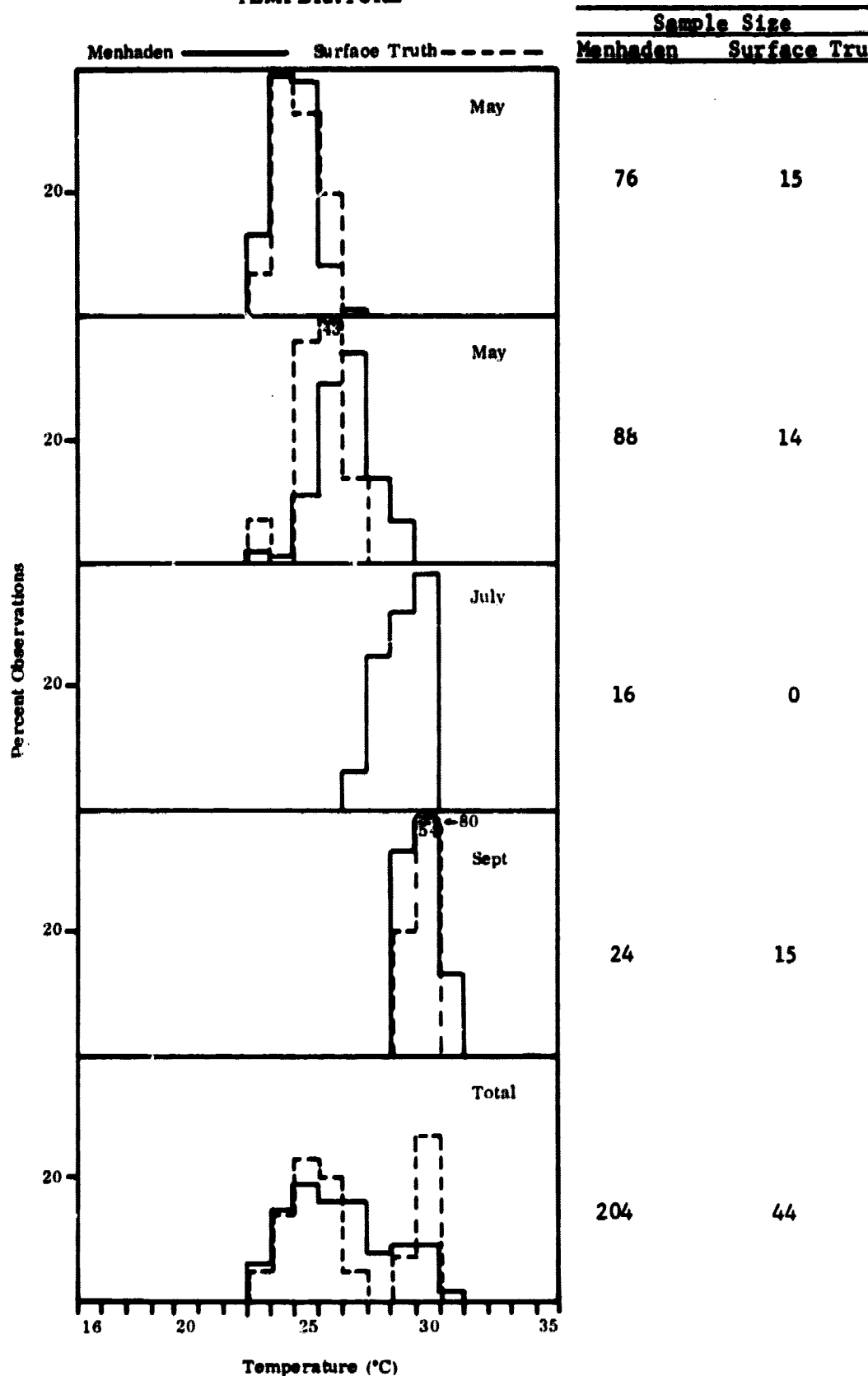


Figure 5.13 Comparison of Surface Temperature Measurements from Sites of Menhaden Capture (solid lines) and Oceanographic Stations (broken lines) in the Mississippi Sound

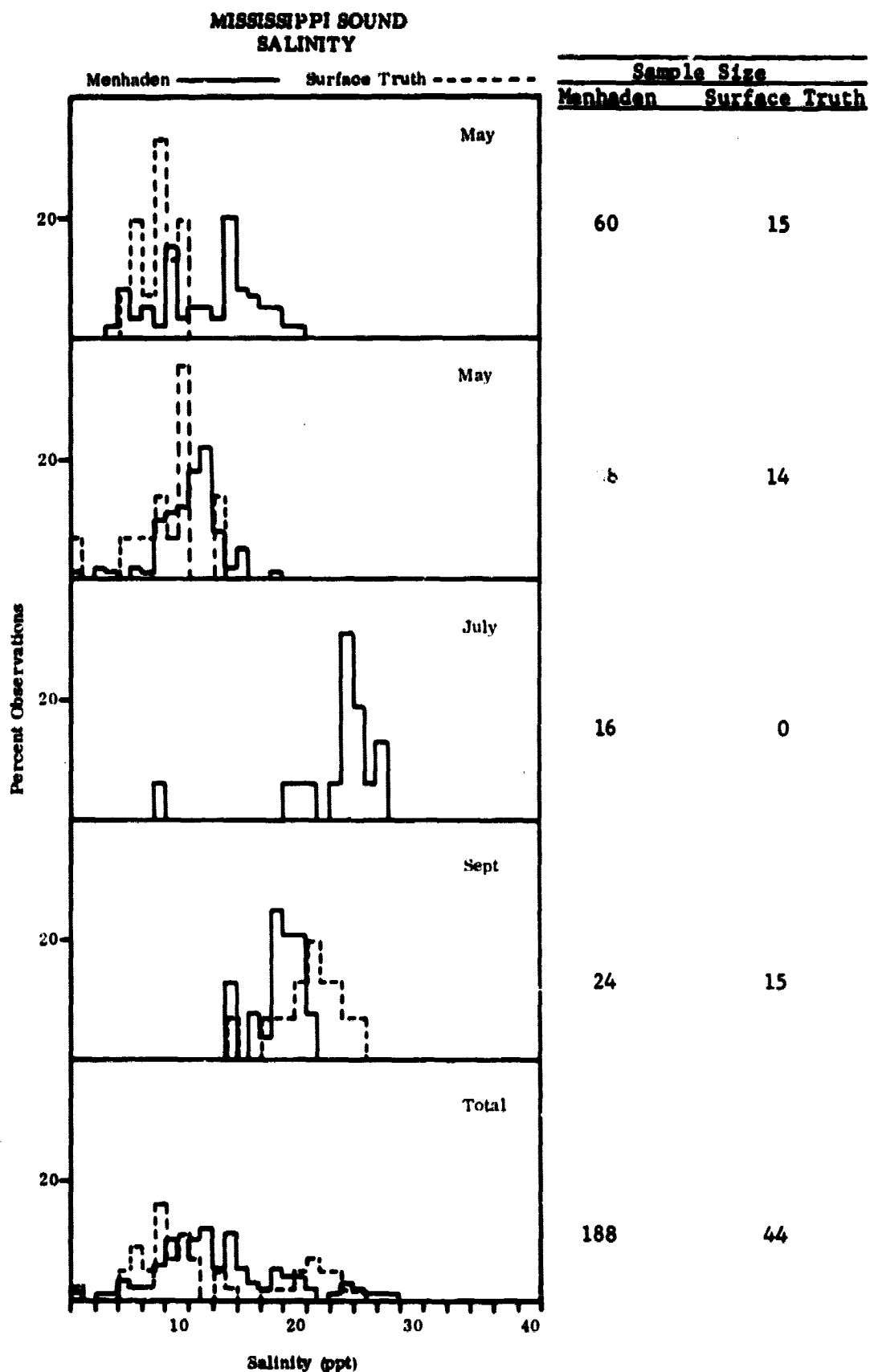
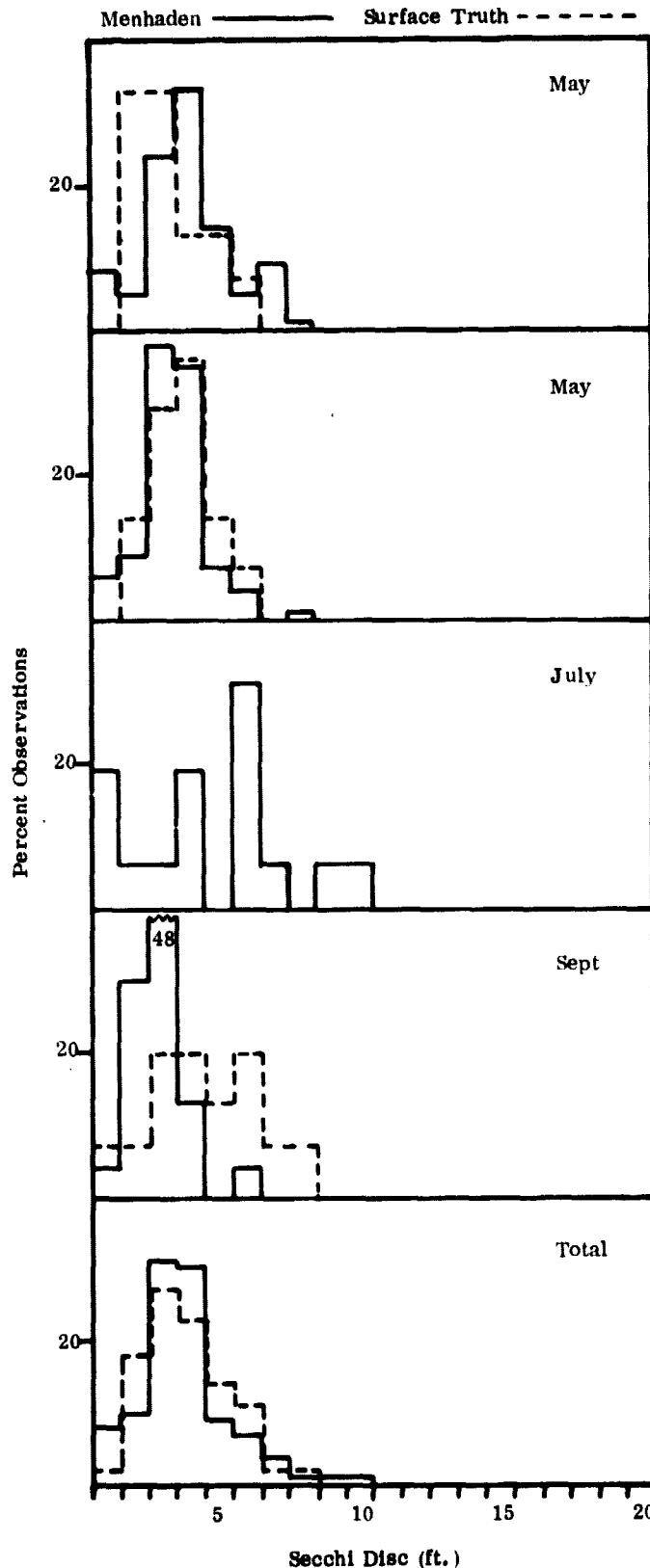


Figure 5.14 Comparison of Salinity Measurements from Sites of Menhaden Capture (solid lines) and Oceanographic Stations (broken lines) in the Mississippi Sound

MISSISSIPPI SOUND SECCHI DISC



Sample Size	
Menhaden	Surface Truth

76	15
----	----

84	14
----	----

16	0
----	---

23	15
----	----

199	44
-----	----

Figure 5.15 Comparison of Secchi Disc Measurements from Sites of Menhaden Capture (solid lines) and Oceanographic Stations (broken lines) in the Mississippi Sound

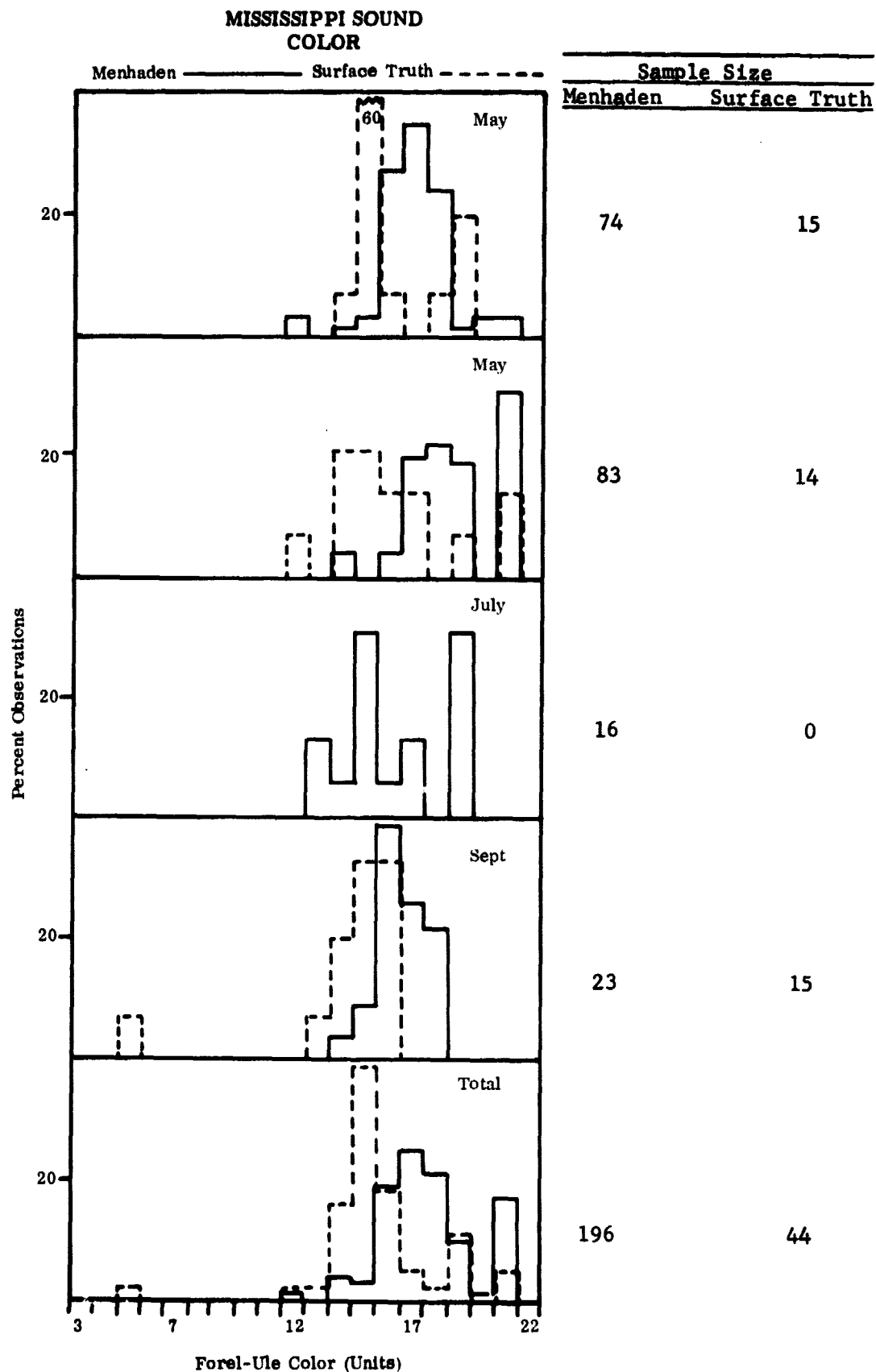


Figure 5.16

Comparison of Forel-Ule Color Measurements from Sites of Menhader Capture (solid lines) and Oceanographic Stations (broken lines) in the Mississippi Sound

COMPARISON OF CONDITIONS BETWEEN TEST SITES WHERE MENHADEN WERE CAUGHT

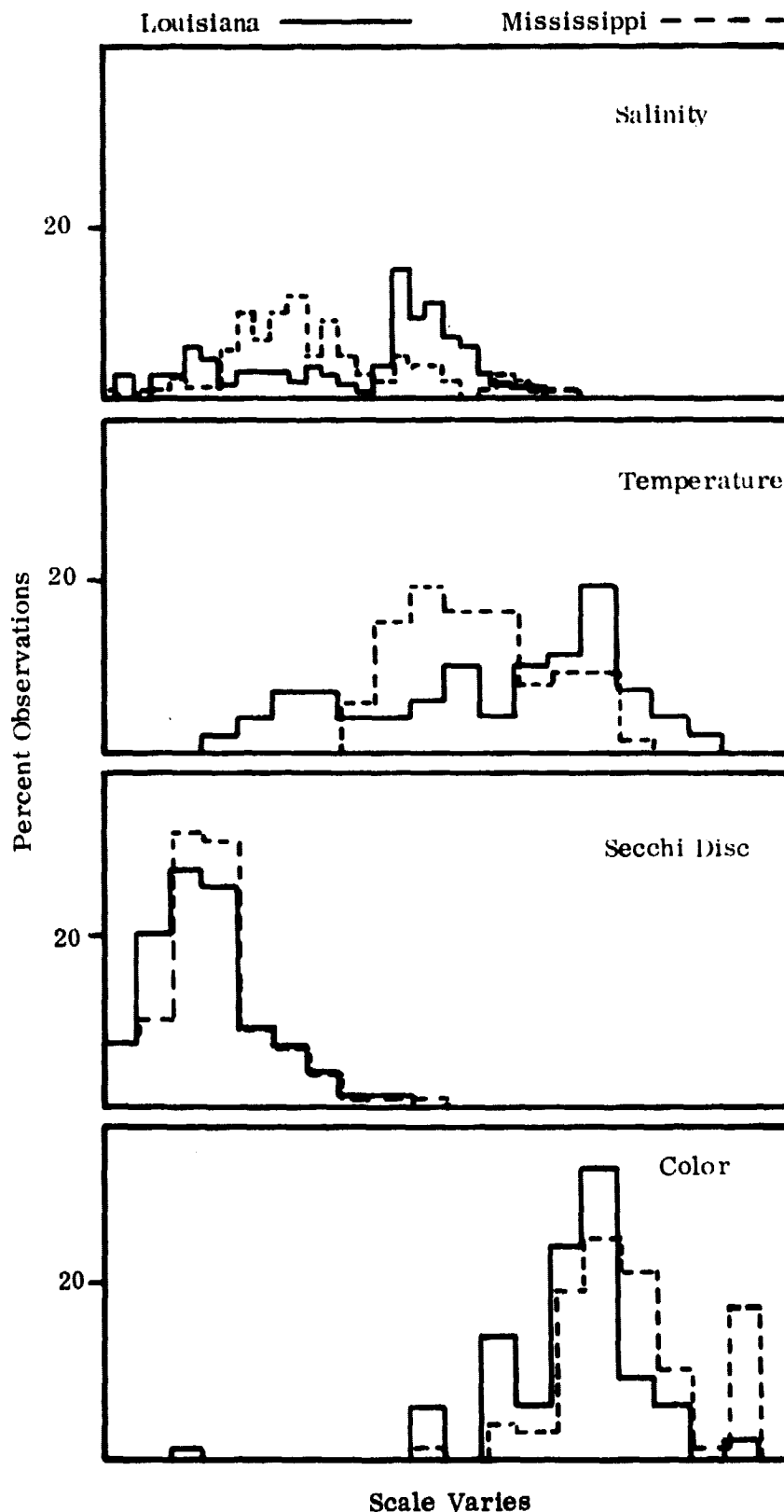


Figure 5.17 Comparison of Selected Measurements of Oceanic Conditions at Sites of Menhaden Capture between the Louisiana (solid lines) and Mississippi Sound (broken lines) Test Sites

6. SIGNIFICANT RESULTS

The most significant achievement realized by this investigation thus far has been the successful completion of the data acquisition phase. This success must be attributed to the interest, support, and competency of the participants.

The apparent consistency of water color and turbidity conditions over time and between test sites at sites of menhaden capture is significant especially since color is readily measured with satellite and aircraft sensors and a LANDSAT MSS based computer model for inferring turbidity has been developed (reported in first progress report).

7. REPORTS, PUBLICATIONS, AND MEETINGS

No formal reports or publications have been prepared over the last three months which relate directly to this investigation. A formal meeting, however, was held on October 16, 1975 at NSTL with industry and other investigation participants. The primary purpose of this meeting was to review the status of the LANDSAT Investigation with the NFMOA fishing vessel captains and spotter pilots.

8. PROBLEMS

Clouds will interfere with the analysis of LANDSAT data for all of the main day missions. The only main day mission completed where cloud coverage probably will have minimal impact is May 20, 1975 (Mississippi Sound). Aircraft RS-18MS data from the ERL Beechcraft are available as back-up for LANDSAT MSS data in all instances, but use of these data will require processing a much greater volume of data than originally anticipated. Use of the RS-18MS data may result in possible analysis delays and budget problems.

9. RECOMMENDATIONS

No recommendations are presented at this time.

10. FUNDS EXPENDED

Purchase orders and other expenditures directly attributable to this investigation total \$184,154.

11. DATA USE

Table 11.1 summarizes LANDSAT 1 and 2 data ordered in support of this investigation. These data are being used to establish relationships between the distribution of menhaden and thread herring and their environment as manifested in the spectral bands.

Table 11.1 Summary of LANDSAT Data Status

Mission Date	Satellite	Ident. Code	Data Quality	Value of Data Ordered (\$)		
				Pos.	9"X9" Transparency Neg.	CCT
April 25	I	5006 - 15485	Fair	20	24	200
May 2	II	2100 - 15445	Poor	20	24	-
May 13	I	5024 - 15480	Fair	20	24	-
May 20	II	2118 - 15448	Good	20	24	200
May 21	II	5024 - 15473	Good	20	24	-
June 18	I	?	Not recieved	20	24	-
June 25	II	2154 - 15450	Excellent	20	24	200
July 24	I	5096 - 15435	Good	20	24	200
July 31	II	1290 - 15442	Not received	20	24	-
August 11	I	?	Not received	20	24	-
August 18	II	2208 - 15435	Not received	20	24	-
August 20	II	2210 - 15554	Not received	20	24	200
Sept 5	II	?	Not received	20	24	-
Sept 16	I	?	Not received	20	24	-
Sept 23	II	?	Not received	20	24	-
TOTALS				300	360	1,000
GRAND TOTAL						1,960

12. AIRCRAFT DATA

Table 12.1 summarizes the status of data acquired with sensors aboard the NP3A. These data are being used primarily for computing salinity conditions in the two test sites.

Table 12.1 Aircraft Data (NP3A) Status

Mission Date 1975	Microwave		PRT-5		M ² S		Photography (Boresight)	
	Status	Quality	Status	Quality	Status	Quality	Status	Quality
April 25	In lab	?	Not rec'd	?	In lab	?	In lab	Poor
May 2	In lab	?	Not rec'd	?	NA	NA	In lab	Poor
May 13	Not rec'd	?	Not rec'd	?	In lab	?	In lab	Poor
May 20	In lab	Good	Not rec'd	?	NA	NA	In lab	Poor
July 24	NA	NA	NA	NA	NA	NA	NA	NA
July 31	NA	NA	NA	NA	NA	NA	NA	NA
August 20	Not rec'd	?	Not rec'd	?	In lab	?	Not rec'd	?
Sept 5	Not rec'd	?	Not rec'd	?	NA	NA	Not rec'd	?